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THE EUROPEAN TACTICAL AIR CONTROL SYSTEM
VERSUS
COMMUNICATION JAMMING

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

PAUL H. MILLER, Major, USAF
B.A., State University of Iowa, 1967

Fort Leavenworth, Kansas
1980

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Recommendations developed include a change in command status of USAF close air support forces, expansion and modernization of our non-radio communications, and formation of an artillery/Combat Electronic Warfare and Intelligence team to counter the Soviet radioelectronic combat forces. (author)

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Communication Jamming.

(Paul H. Miller), Major, USAF
U.S. Army Command and General Staff College
Fort Leavenworth, Kansas 66027

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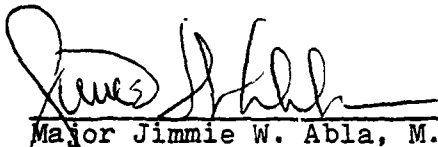
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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

THE EUROPEAN TACTICAL AIR CONTROL SYSTEM VERSUS
COMMUNICATION JAMMING, by Major Paul H. Miller, USAF,
67 pages.

This study is an examination of how current close air support doctrine, when opposed by Soviet/Warsaw Pact radioelectronic combat capabilities, impacts the U.S. Air Force's ability to closely support the ground commander in Central Europe. Addressed are the current system for close air support, system-induced problems, enemy-induced problems, and several non-doctrinal recommendations for solutions to these problems.

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CHAPTER 1

INTRODUCTION

Under nearly any Central European war scenario currently imaginable, the United States Air Force's tactical air control system's communications are inadequate to successfully fight the close air support battle. With this thesis comes a central assumption that what is known of Soviet radioelectronic combat (REC) capability is not only reasonably accurate, but also that the Soviet/Warsaw Pact will use these capabilities to their fullest in any such armed conflict. In examining this thesis, the author will review how the U.S. Air Force (USAF) currently intends to perform close air support (CAS), the difficulties with the plan, and what must be done to retain or regain capability to communicate. As the author's experience for the last twelve years lies in positions having directly to do with close air support fighter aircraft, that model will be the vehicle used for illustration throughout. Specifically, the concern is with the Soviet Front's capability to jam or destroy the communications of the Tactical Air Control System (TACS) in Germany and the inability of U.S. forces to cope with this threat.

The TACS is the U.S. Air Force's basic plan to efficiently control the theater air battle. This network of communications is key to the Air Force component commander's ability to mass and maneuver his fires to most effectively support the ground forces in their prosecution of the land battle. However, in the European theater and particularly in the two U.S. corps areas in Germany, there is significant evidence that this communications network is as outclassed by Soviet REC forces as our armor is outnumbered by theirs.

If tentative acceptance is granted to Tactical Air Command's assertion that, "All radiated electronics can be countered.", the loss of a large number of key systems is inescapable as the Soviets unleash their array of direction finding and communications jamming equipment in coordination with their assault.¹ Table 1 (TACS Radiated Communications/Jamming Vulnerabilities) is a recital of radiated communication dependent systems which contains many of extreme value to both the air and ground commanders' ability to fight outnumbered. Particularly vulnerable are the rapid response systems which largely depend on airborne platforms with single mode or single frequency band radios.

¹Tactical Air Command Manual 2-1, Operational Doctrine:
Tactical Air Operations (Langley AFB, VA: 15 April 1978),
p. 5-5.

Table 1

TACS RADIATED COMMUNICATIONS/JAMMING VULNERABILITIES

System	UHF	VHF	VHF-FM	HF	LF
Airspace Control	X	X	X	X	
Tactical Air Control Parties (TACP)	X	X	X	X	
Strike Control and Reconnaissance (SCAR)	X			X	
Weather Data Nets	X	X	X	X	
Airborne Command and Control (ABCCC)	X	X	X	X	X
Datalinks		X			
LORAN					X
Ground Controlled Approach (GCA)	X	X			
Instrument Landing System (ILS)		X			
Tactical Air Navigation System (TACAN)	X				
VHF Omni-directional Range (VOR)		X			
Airborne Warning and Control System (AWACS)	X	X	X	X	X

The impact of the loss or degradation of these systems is not totally quantifiable, but certainly can, with sufficient accuracy for argument, be subjectively assessed as staggering. Loss of the use of the Instrument Landing System (ILS), Ground Controlled Approach (GCA), Tactical Air Navigation System (Tacan), VHF Omni-directional Range (VOR), and air traffic control nearly restricts air assets to clear air operations. For the European theater, with its habitually poor weather, this could mean long periods where air support would be reduced to near zero. Losing the vast array of datalinked intelligence gathering systems would severely reduce U.S. commanders' ability to see deep into the Soviet echelons and would thus greatly enhance the enemy's capability for surprise. The implications of the loss of the Army's tactical networks will be discussed only as it pertains to the air support process. Suffice it to say, at this point, the highly mobile forces of the Army and the tactical air control parties (TACPs) supporting them would be nearly useless without communications and those they normally use are eminently jammable.

However, the assumption that all radiated electronics can be countered does not necessarily mean that they all will be. Many of these systems are far behind the main battle area and thus the success of enemy jamming

is less probable, except for the isolated cases of air assaults and clandestine or airborne jammers. Furthermore, in many cases the Soviets will prefer to listen to our non-secure communications rather than to jam them. Add to these realities, the un-jammable and jam-resistant systems in the U.S. inventory and the picture may be less in the Soviet's favor. The remainder of this paper is focused on these areas of higher probability of communications difficulty and the remedies that are or , hopefully, will be available to alleviate them.

CHAPTER 2

TACTICAL AIR CONTROL SYSTEM

(TACS)

The TACS is the Air Force component commander's "command, control, communications, intelligence, and interoperability (C³I²)" network.¹ For the purposes of this paper, this is the same as the Army's concept of "command and control and communications (C³)", merely adding greater emphasis to intelligence and the need for interoperability.² The emphasis is on command and control communications. The TACS network is the central command and control medium for the widely spaced variety of radars, tactical units, and airlift which make up the airpower of the theater. The communications assets to do this are owned and operated by the Air Force at Army echelons down to battalion and at Air Force units at all levels. What this network does, and what it uses to do it, are the subjects of this chapter.

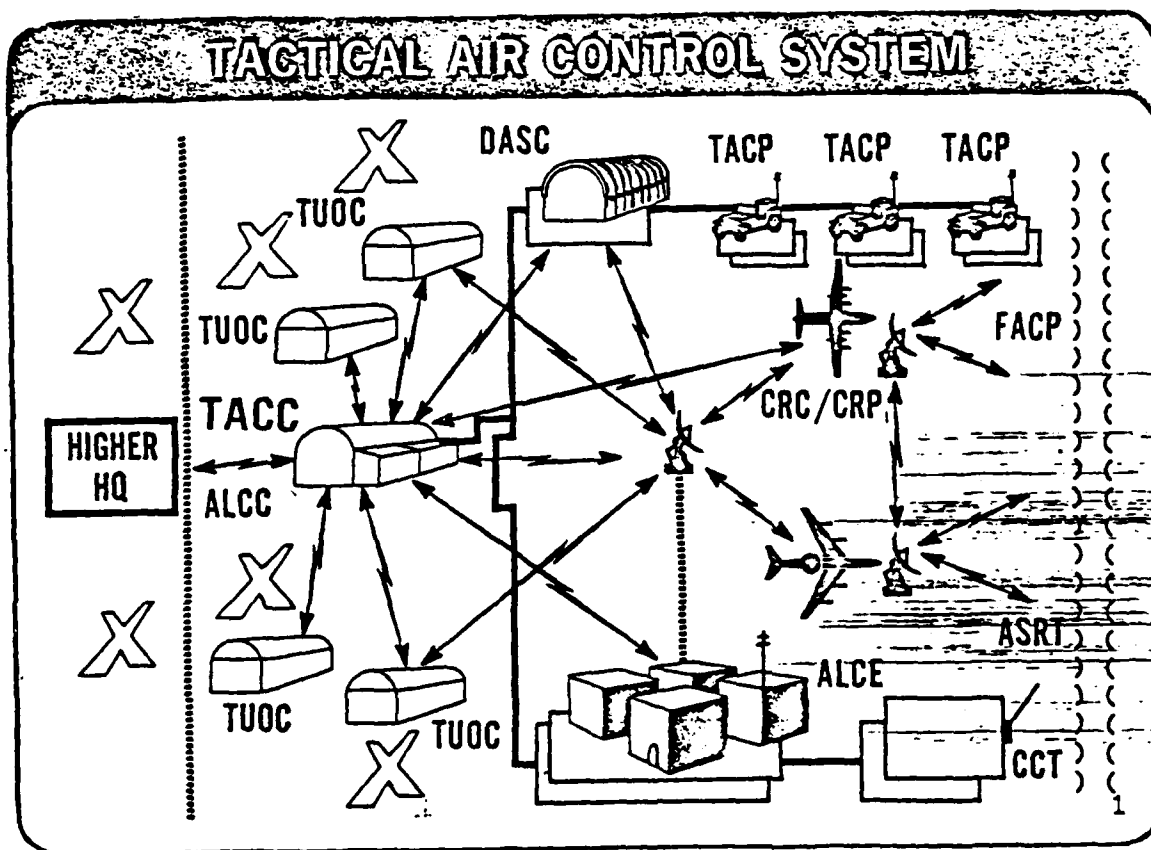
Above all, this network communicates to control air assets in the most efficient use of airpower to influence the battle.

¹Tactical Air Command Manual 2-1, p. 3-1.

²U.S. Army Field Manual 24-1, Combat Communications (Ft. Gordon, GA: U.S. Army Signal School, 30 September 1976), p. 1-2. The Army also couples additional items with C³, often intelligence and sometimes electronic warfare.

With the highly mobile nature of modern combat and in particular , aircraft, C³I² must depend upon equipment more portable than the telephone. Figure 1 illustrates the current communications concept of the TACS.

Figure 1



¹Tactical Air Command Manual 2-1, p. 4-41.

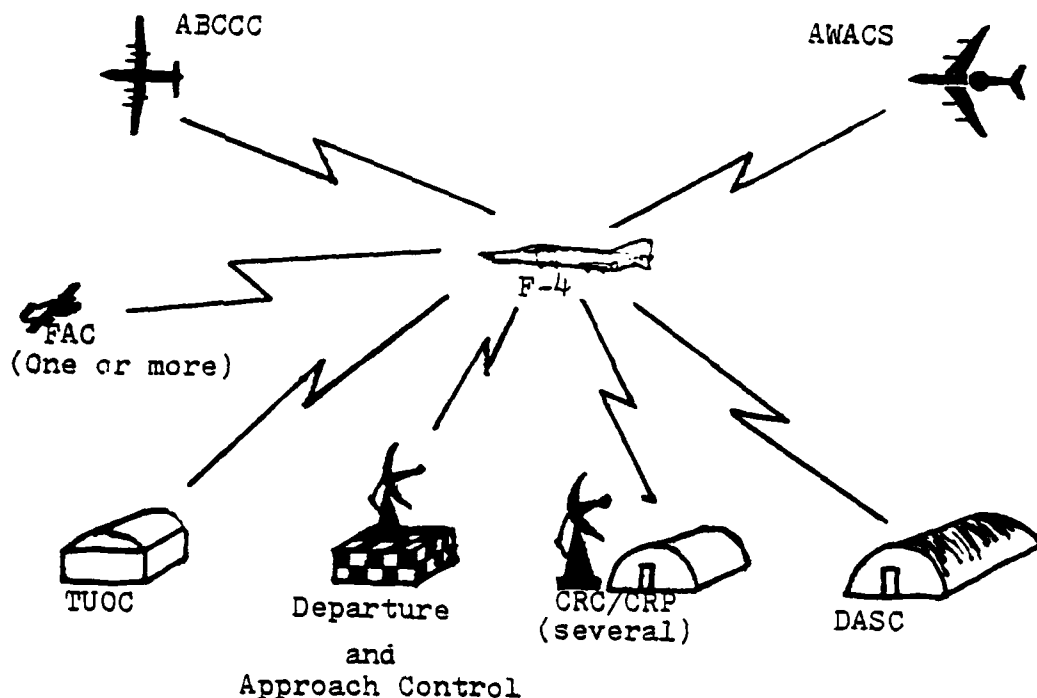
Abbreviations from Figure 1

DASC- Direct Air Support Center
TACP- Tactical Air Control Party
FACP- Forward Air Control Party
CRC- Control Reporting Center
CRP- Control Reporting Post
ASRT- Air Support Radar Team
AWACS- Airborne Warning and Control System
CCT- Combat Control Team
ALCE- Airlift Control Element
TUOC- Tactical Unit Operations Center
ALCC- Airlift Control Center
TACC- Tactical Air Control Center
ABCCC- Airborne Command and Control Center¹

Although landlines are used wherever possible, there is great dependence on radios to link the highly mobile portions of the net. Note that Figure 1 does not cover all the communications of the TACS; missing are the fighter aircraft links to and from the agencies portrayed. Therefore, Figure 2 shows how an average, uncomplicated close air support sortie in Central Europe might use radio communications. For the F-4 pictured, all of these linkages are via UHF-AM radio. Critical to CAS mission success are the FAC and DASC communications, with others having lesser impact aside from exceptional circumstances. Other, newer fighters may also use VHF-AM and VHF-FM radiated communications to establish the same linkages.

¹Tactical Air Command Manual 2-1, Chapter 4.

Figure 2



In peacetime, double or triple the number of agencies must be consulted by radio. Rarely does an aircrew take off knowing all essential mission details, even if permission to expend munitions was granted in advance.

Therefore, the TACS performs its C^3I^2 mission using nearly every known variety of communications gear, with heavy emphasis on radio. This dependence is due to the system components' mobility and the requirement for extreme responsiveness to meet the Army's rapidly changing need for airpower.

The TACS' wide variety of communications assets is best explained by the term "interoperability". If the TACS is to be able to interface with the Army, the Navy, the Marine Corps, and our allies, its equipment must be able to interface with the communications equipment evolved to best answer the needs of those other services. After one adds to these Army, Navy, Marine Corps, and allied peculiarities, the Air Force's own family of frequencies and modulations for voice, data-link, relay, and secure transmission, one will find that there are not many types of communications missing from the TACS network.¹

¹For further information on who talks to whom on what communications mode and why, see Tactical Air Command Manual 2-1 or Appendix D to U.S. Army Field Manual 6-20, Fire Support in Combined Arms Operations(Ft. Sill, OK: U.S. Army Field Artillery School, 30 December 1977).

CHAPTER 3

DIFFICULTIES CONFRONTING THE TACTICAL AIR CONTROL SYSTEM

This network, as with anything military, has difficulties arrayed against it. And as elsewhere, these difficulties come from two main sources, self-induced and enemy-induced. This chapter is an examination of these problems, their extent, and their effects.

Self-induced problems are classified as interference and are, in the majority, caused by some other legitimate user of that portion of the radio frequency spectrum. Interference problems stem from the sheer numbers of radios used in modern warfare and from the need to have the majority interoperable. Whether or not the perceived requirement for this large number of radios is a cause or a result, the visible product is a great many people armed with radios and a perceived, pressing need to communicate with someone at the same time, on the same frequency, and using the same modulation technique. This results in self-jamming as each person, convinced of his priority, attempts to drive his message through by transmitting too often and too long.

Two studies indicate that an armor battalion having no major difficulties and with "good" communications discipline can be expected to transmit or receive approximately 733 messages via radio per 24 hour period. The average duration of each message is two minutes. This results in roughly $24\frac{1}{2}$ hours of message traffic per battalion spread over the 12 radio nets normally found.¹ This message rate of about one every two minutes may be multiplied by the number of battalions locally and by the number of similar enemy and friendly FM nets simultaneously in operation. Further compounding the congestion is the fact that most Army communications are in the narrow frequency range of 30-76 megahertz.² The resulting message traffic density virtually guarantees that the Army (the primary U.S. FM user) will be jamming itself at least some of the time.

¹U.S. Army Combined Arms Center, Communications Support Requirements (COMSR) (Computer Sciences Corporation, 1973), pp. A-II-74-5 through 12 and Modern Army Selected Test, Evaluation, and Review, Staff Organization and Procedures, Test 119 (1974), pp. 328-341 quoted in John W. Beaver, "An Analysis of Alternatives to Verbal FM Tactical Command and Control Communications" (Masters Thesis, U.S. Army Command and General Staff College, 1975), p. 18.

²U.S. Army Training and Doctrine Command, Threat Monograph: Jamming of FM Tactical Communications (Ft. Monroe, VA: 1977), p. 7.

When problems arise in combat, that "some of the time" becomes much more of the time. This often happens in the Army, even in peacetime exercises, and presages difficulty for the Air Force's communication system that interfaces with the Army's air-ground operations net. The Air Force is also subject to this syndrome. The best illustration of this susceptibility is that the UHF emergency frequency (243.0 megahertz) was often totally unuseable over Hanoi due to the competition for its use by warning agencies, downed aircrews, and emergency locator beacons.¹

In Central Europe, this overuse of radio has taken the TACS several steps further down the road to complete failure. With the massive use of airpower, the USAF has driven the TACS well beyond its peak load capability just for air traffic control reasons. During the Reforger exercises of 1977 and 1978, the author's squadron of dual-based F-4s was normally ineffective (mission not successful) four times out of five due to the European TACS' lack of communications capability to control the heavy air traffic into and out of the battle areas and tactical airfields.²

¹Personal experience, but also see Jack Broughton, Thud Ridge (New York: J.B. Lippincott Co., 1969), p. 110.

²Even though dual-based squadrons are only in Europe one-two months per year and their results may not be matched by European-based squadrons, these results are certainly indicative of the European TACS' difficulties in even a non-jamming environment.

This failure rate also includes the TACS' inability to connect the air or ground forward air controller (FAC) with their inbound air assets. The problem always worsened with the weather as the fighters were forced to rely more completely on the radars and communications of the TACS to get them safely below the clouds both to attack and to land. This overload and its attendant delays forced the fighters to increase the amount of on-board fuel reserved for recovery, thereby decreasing their time-on-station and their effectiveness. Efforts are continuing toward solving this difficulty with extra radios and navigation aids both on the ground and in the aircraft. While these efforts may mitigate the immediate overload problem, they will only slightly complicate the enemy's radioelectronic combat problem while adding more electronic competition to the friendly problem in the long run. The enemy portion of the TACS' difficulties will be dealt with later in this chapter.

Another communications trauma that can be self-induced is the effect of the electromagnetic pulse (EMP) resulting from a nuclear explosion. The Compton-electron effect produces an electromagnetic surge or flash of awesome proportions.¹

¹Office of Civil Defense, EMP Protection for Emergency Operating Centers (Washington: 1971), pp. 1-7.

This pulse rapidly induces very high voltage into any piece of wire not protected. Although actual figures of voltage build-up and pulse length are classified, current U.S. government nuclear hardening specifications for communications equipment call for the capability to withstand induced surge voltages up to 10,000 volts per meter.¹ The EMP wipes out communications for the duration of the pulse and, if the equipment is unprotected, may damage it regardless of whether the equipment is turned on or not. This is an even more appropriate worry for the U.S. than for the Soviets, because our transistor and solid state circuits are much more vulnerable to the effects of EMP than are their vacuum tube devices.²

The duration and effects of the EMP are variable, dependent upon the type of blast, height of burst, size, distance, and vulnerability of the device in question. A considerable body of classified research suggests that while we have a fairly solid idea of how EMP works, the lack of above-ground nuclear testing has left large parts of this area in the purely theoretical realm.³

¹Marion A. Rose, "Part III, Nuclear Hardening of Weapon Systems" Defense Electronics, November 1979, p. 66.

²Donald B. Dinger, Nuclear Electromagnetic Pulse Effects on Army Materiel (Research for Electro-technology Laboratory, Ft. Belvoir, VA: 1969), p. 1. (SECRET)

³Tactical Air Command Manual 2-1, p. 6-5.

Rather naturally, if efficiency is gained with communications, the enemy will attempt to deny their use. The first use of radio communications jamming was done by the British against the Afrika Corps in November 1941. It was done from converted bombers and was so effective that the Luftwaffe units in the area devoted several days to finding and shooting them down.¹ Since then, scientists have continued their efforts on up the technological scale. A U.S. Air Force report says, "Present and projected jamming threats will severely hamper and, in most cases, completely negate all voice communications."² U.S. Army Field Manual 1-2 states that the Soviets plan to destroy one-third of U.S. command and control communications, jam one-third, and listen to the rest.³ In 1979-1980, the U.S. Army Command and General Staff College taught that the Soviets planned on "at least 50 percent destroyed or degraded".

¹U.S. Army Training and Doctrine Command, Jamming of FM Tactical Communications, p. 3.

²Donald L. Clough and Donald I. Zulch, "Project Seek Screen: Executive Summary" (Technical Report for Rome Air Development Center, Griffiss AFB, NY: 1976), p. 1. (SECRET)

³U.S. Army Field Manual 1-2, Aircraft Battlefield Counter-measures and Survivability (ABCS) (Baltimore: 7 July 1978), p. 59.

Regardless of information source, if command and control communications are "the force effectiveness multiplier", then communications jamming is certainly the force effectiveness divisor.¹ Even without citing the classified numbers of Soviet communications warfare assets, it can be clearly seen that this is indeed a formidable obstacle to our efficient use of tactical airpower.

The enemy air defense threat to U.S. aircraft, in large measure, dictates U.S. close air support tactics. If these resulting tactics increase the difficulty of communications, then the enemy's air defense effort also has communications warfare aspects. This is particularly well illustrated by current Air Force tactical thinking on how to perform high threat area close air support (CAS). Tactics against the SA-6 through 9 surface-to-air missiles and the ZSU-23-4 gun systems counsel descent to the lowest practical altitude prior to entering their coverage. This low altitude, high speed approach may also be selected to attempt some measure of surprise by flying under the early warning and ground controlled intercept (GCI) radar coverage.

¹Tactical Air Command Manual 2-1, p. 3-3.

The actual height of this lowest practical altitude is situationally dependent, but to be effective must be around 100-200 feet above ground level (AGL) with further descent to 50 feet AGL if fire is received. This low altitude greatly reduces the distance to the horizon and thus the range of the fighter's line-of-sight radio. Couple this lack of range with the fighter's lack of staying power due to greatly increased fuel consumption at low altitude and the discovery that there is little time left for coordination with forward elements prior to the attack becomes inevitable.

The line-of-sight radio difficulty is compounded by the aircrews' desire to keep some piece of terrain between themselves and the enemy defenses until the very last seconds; for where the enemy is, there also will be the Army and the need for closely supporting airpower. Note that if the Air Force is adequately hiding from enemy radars and communications jamming, they will also be cutting off communications with those they have come to aid.

The situation deteriorates further as consideration of the aircrew workload forced by the air defenses is added.

At 100 feet AGL, a quarter second lapse of attention can mean a quick and totally terminal contact with the ground. Add to all of the above, the requirements to maintain a mutually supportive formation, evade defenses, talk to several controlling agencies, and still effectively employ a difficult, sometimes recalcitrant, weapons system and the sum becomes a problem that takes years of expensive training to even begin to overcome.

The TACS faces problems from both friends and enemy. The particular factors of radio density and lack of sufficient available frequencies to accommodate all users continue to be problems, but they are under attack. Research on nuclear burst phenomena continues, along with hardening of our communications equipment against this threat. Aircrew workload is being reduced by human engineering experts and increasingly automated avionics. But with few significant exceptions, enemy efforts are met with little more than wishful thinking. Although the Air Force continues to upgrade the quality and maintainability of radios in aircraft, essentially nothing has been fielded to increase the jam-resistance of airborne communications. There has likewise been little training in how to handle close air support in a communications jamming environment. All of the arguments for training as we propose to fight are operative in this context.

An example may be helpful. At the Tactical Air Command's most realistic training effort, the Red Flag exercise series, communications jamming is limited to the point of ineffectuality by artificial rules of engagement. This, according to Red Flag staff officers, is because of safety considerations and the fact that no other training can be accomplished when the relatively low power communications jammers shut down the use of airborne radios.¹

The Army is not exempt from this ostrich-like reaction to the Soviet's radioelectronic combat capability. This is well illustrated by the fringe Army organization of the Combat Electronic Warfare and Intelligence battalion. Granted the creation of a special type of unit to handle this problem is some response. however the fact that they are attempting to operate with jerry-built equipment and the ignorance, if not disdain, of the combat arms officers indicates that the Army is not really serious about this problem either. Further, there is no evidence of any practice of communications warfare in the U.S. Army's largest exercise series, the annual European Reforger war games.

¹Donald J. Waters, Seek Talk Jammer Support (Technical Report from Rome Air Development Center, Griffiss AFB, NY: January 1978) p. 4. (SECRET)

While this is in part due to the tactical FM radio's frequency proximity to German commercial television, it remains that no U.S. forces have been trained to deal with active hostile communications warfare on the terrain considered by many to be the next battleground.¹

Additionally, there is no delineation of whom, Army or Air Force, is responsible for battlefield suppression of enemy communications jamming assets. A letter from the Army's Director of Requirements indicates that electronic warfare liaison among the Army, Air Force, and NATO allies is, as of Spring 1980, just in the development and study stage.²

Now, whether all this is a result of a true "head-in-the-sand" attitude or a "technological" grass is always greener five years downstream" syndrome is immaterial. The threat remains, and the United States has done little to counter it, save theoretical studies. There are, however, some efforts at mitigating the impact on our communications capability. What these are, why they are grossly inadequate, and what should be done are the subjects to which the remainder of this paper is devoted.

¹The 101st Airborne Division, Reforger 76 After Action Report: Vol I - Executive Summary (Fort Campbell, KY: 10 December 1976), p. 2-5.

²Fred K. Mahaffey to E.G. Fubini, Washington, 10 March 1980.

CHAPTER 4

COMMUNICATIONS JAMMING:

CURRENT SOLUTIONS

The purpose here is to briefly address current USAF and Army answers proposed to counter the communications warfare threat, both to the TACS and to the Army communications which interface with it. First, the author will identify the answers and briefly explain how each is supposed to help. Secondly, the inadequacies of these answers will be pointed out in terms of why each reduces U.S. ability to efficiently wage war and why they collectively constitute an acceptance of the Soviet/Warsaw Pact's radioelectronic combat superiority.

At the head of nearly all the lists of immediately available actions to reduce the effectiveness of communications jamming, one will find terrain masking. With the wide use of systems requiring the establishment of line-of-sight between transmitter and receiver, the clever use of terrain can reduce the effects of enemy jamming. By maintaining a horizon between the receiver/transmitter pair and the enemy's jamming and direction finding equipment, the Soviet radioelectronic combat forces will not be able to detect and locate the transmitter or to jam the receiver.

This does indeed work, but it also imposes restrictions which, in some cases, accomplish the enemy's intent just as surely as if line-of-sight access and totally effective jamming were granted. First, the geometry of establishing a horizon between a friendly network and the enemy demands convenient terrain, low aircraft altitude, large distances from the forward edge of the battle area (FEBA), or some combination of the above.

Finding convenient terrain to hide behind while communicating is possible, but situation dependent and much more difficult at 500 knots than on the ground. In other words, not something upon which one can depend. Large distances from the FEBA are certainly achievable, but, even with available stand-off weapons, do not greatly contribute to damaging the enemy. Low altitude is thus the only friendly-controlled method of forcing a horizon between a friendly network and the enemy, i.e., the only totally controllable means of terrain masking. And if low altitude tactics are used to get close enough to the battle to perform the mission, the effects on mission critical equipment is reduced utility and efficiency. For example, the side-looking radars of the RF-4C and OV-1D with their attendant downlinks lose stand-off range, coverage, and effectiveness as altitude is reduced.

The RF-4C tactical electronic reconnaissance system (TEREC) and the E-3A AWACS lose capability in the same way. The second factor which may diminish expected return from terrain masking is the augmentation of the Soviet Tactical Air Armies with greatly increased numbers of airborne jamming platforms. According to the U.S. Army Intelligence and Threat Analysis Center, the extent of the addition is several squadrons of aircraft for each Soviet Tactical Air Army (normally associated with each Front).¹ These platforms have the capability to intercept and to jam our communications, and with their mobility, can deny many of the U.S. forces' opportunities to use terrain and geometry to avoid jamming.

A second operational technique which may be used to mitigate enemy communications jamming efforts is to plan on a total defeat of communications, i.e., tactical plans and procedures set up such that no communications are radiated. In other words, have all coordination completed by land-line or face-to-face prior to operation start and then use visual signals during the execution phase.

¹U.S. Army Intelligence and Threat Analysis Center and the BDM Corporation, Soviet Army Operations (Washington: April 1978, pp. 2-21 and 5-83. Also Tactical Air Command Manual 2-1, p. 2-8.

This no-communication tactic has been successful many times in interdiction scenarios (beyond the FSCL) and by the Army's observation/attack helicopter team.¹ There are undoubtedly many other examples of radio silence as a tactic, but in the world of Air Force close air support, the mission can not be accomplished without radio communications.² The critical need for rapidity of response to the changing ground situation and the time/distance from the tactical airfields to the target makes rapid, portable communications an absolute necessity. Creek Braille, a Fourth Allied Tactical Air Force/U.S. Fifth Corps plan initially, attempted to reduce close-to-FEBA radio communication with the use of pre-planned "kill zones." But even with the success of that effort, in the final phases of an attack using these procedures, the rules of engagement still required air/ground communication via radio. Further limiting the usefulness of this technique was the necessity of maneuvering the enemy onto the desired ground zero of the kill zone.

¹James C. Kantor, Air Cavalry/Attack Helicopter Team Communication Interference Control Cards (CICC) "KICK" Concept Evaluation (Ft. Knox, KY: U.S. Army Armor and Engineer Board, 29 December 1977).

²Tactical Air Command Manual 2-1, p. 4-34.

Regardless of the Soviets' marked preference for high speed advances through favorable terrain, no intelligent ground commander is going to allow such gross concentration of his forces at the pleasure of his enemy. And if he does, his successor almost certainly won't. This argument and one other were demonstrated during the Reforger/Carbon Edge exercise in the fall of 1977. During exercise play, the orange forces pushed the blue forces (NATO) back through the line of kill zones with such speed and in such poor weather that literally no missions were flown on the kill zones that could be classified as other than interdiction (i.e., beyond the FSCL).

Therefore, while terrain masking will aid in overcoming enemy radioelectronic combat, it is inadequate, both because it sidesteps the central struggle for communications control and because it exacts too high a price for its use.

Low probability of intercept techniques are another admission of Soviet communications warfare superiority. These techniques are, however, a frequently cited way of reducing the effects of enemy jamming.¹

¹See among others U.S. Army Regulation 105-2: Electronic Counter-Countermeasures (ECCM) Electronic Warfare Susceptibility and Vulnerability (Washington: 30 September 1976), p. 5. (Confidential).

This set of procedures is analogous to two boys raiding the cookie jar while mother naps, i.e., keep very quiet and she'll never know. In the real world, this means operating radios as little as possible and at as low power output as possible. The fact is that "Mother" Russia is wide awake and is listening with 13 times the number of ears possessed by opposing U.S. forces.¹ Now, bear in mind all that ground equipment, add to it the previously mentioned squadrons of airborne direction-finding and jamming platforms, and the true fragility of this argument should become clear.

The use of multiple frequencies and multiple communications modes as backups is also a often cited way of evading communications jamming. This is based on the hope that the Soviets cannot possibly be listening to, jamming, or directing artillery onto everything that radiates. While this is undoubtedly partially true, this researcher has found nothing which even begins to explain why the Soviets, at times and places of their own choosing, will not be logistically able to concentrate adequate artillery to deal with the garrulous Americans communicating at their rate of one or more messages every two minutes.²

¹General John W. Pauly, "The U.S. Air Force in Europe", Speech to Air Force Association National Symposium at Los Angeles, 25 October 1979.

²Beaver, "Analysis of Alternatives to Verbal FM", p. 18.

The last method discussed is to increase transmitted power relative to the jammer(s). This can be done by increasing transmitter output, antenna directivity, or by proximity. For nearly all U.S. communications equipment, increasing the power output of a transmitter is not an option available to the frontline operator, at least beyond selecting a high or low power mode designed into a few systems. For the fighter aircrew, it is not an option at all, since USAF tactical fighter radios have no such cockpit-selectable capability.

Directivity of radiation pattern is another non-answer for the airborne platforms, as steerable beam antennae are not on the airplanes. This approach offers some relief for the Army and the ground non-mobile portions of the TACS as it is effective in reducing intercept probability as well as jamming vulnerability. But, this is only a partial solution because of the degree of coherency achievable with existing systems and the fact that the beamed communications continue well beyond the receiver.¹

However useful and flexible a radiated system may be, it can be countered. And with the U.S. forces'

¹U.S. Army Field Manual 32-30, Electronic Warfare
(Washington: 30 June 1975), p. 3-6. (Confidential)

habitually long lead times for the acquisition and fielding of new systems; other, older, and still operational ways of communicating may play a greater role in restoring the capability to communicate undisturbed by the enemy. The oldest of the non-radiated methods for telecommunications still in existence is wire, which due to the Army's austere manning and wire's labor-intensive quality has lost popularity since World War II in favor of FM radio. General Patton, however, made a special point of wire's value.

In all attacks make maximum use of wire lines and use every effort to keep it up with the advancing units. Radio, while theoretically efficient, is not as good as wire and should be considered as a secondary means of communication.

The General's primary reason for preferring wire was the radio's lack of reliability.¹ The Soviet radioelectronic combat threat places U.S. forces in a very similar position for a different reason.

Another reason for the use of wire is that it cannot be triangulated by radio direction-finding gear and turned over to Soviet artillery. This threat is one for which the Army is going to lay a large portion of its concern directly on the Air Force.

¹General George S. Patton, Jr., War As I Knew It (Boston: Houghton-Mifflin Co., 1947), p. 347.

Currently, the Air Force TACS' communications located with Army units constitute one of the most powerful, most easily traced and located electronic signatures forward of the corps operations center. Since the Air Force locates one of these electronic hot spots at every Army Tactical Operations Center from battalion to division, the U.S. Army's order of battle should be very easy to discern for even a semi-intelligent Soviet commander.

Wire's disadvantages are its need for nuclear EMP shielding, its weight (WD-1 field wire: 48 lbs/mile), physical vulnerability, and the labor intensity of installation.¹ Wire also has a disadvantage in its limited range; battery operated from 14-24 miles, and sound-powered from 6-10 miles.² This range can be extended via relay or satellite crosslink. Satellite crosslinks are vulnerable to jamming, but it is , at least, very expensive to get the inexpensive jammer required into the beam area.³

¹U.S. Army Field Manual 24-20, Field Wire and Field Cable Techniques (Ft. Monmouth, NJ: U.S. Army Signal Center and School, February 1970), p. 10.

²Ibid., p. 3.

³William C. Cummings, Satellite Crosslinks (Lexington, MA: Lincoln Laboratories Technical Note for MIT, 4 August 1978), p. 20.

To review, the currently proposed methods to resist the Soviet/Warsaw Pact radioelectronic combat capability fall into two general categories:

1. Admit communications defeat and try to plan around the total loss of radiated communications.
 - a. Low probability of intercept techniques.
 - b. No-communications tactical plans.
Wire and visual signals only.
2. Optimize signal-to-jamming ratio and hope for the best.
 - a. Terrain masking.
 - b. Increase transmitted power.
 - c. Transmit as directionally as possible.

The inadequacy of these "solutions" is implicit in their nature; the first strategy admits defeat (perhaps communications defeat is tantamount to defeat in battle), and the second can be labeled wishful thinking. While it is not the purpose of this paper to answer the question of why this is so, Dr. Earl Claire of the National Security Industrial Association breaks the reasons into three categories: one, the lack of detailed threat knowledge, two, the tendency to defer action until newer technology becomes available (he labels this the "grass is always greener syndrome"), and third, uncertainty on cost and funding.¹

¹Anti-Jam Policy Study: Vol V: New Anti-Jam Systems
(Washington: May 1978), p. 119.

But regardless of why, the available evidence indicates that with existing ground and air communications assets and the threat capabilities against these assets, there is insufficient communications to perform one of the most important reasons for a separate Air Force--the centralized, responsive management of air assets to efficiently use them theater wide as their inherent mobility allows. This lack also insures the Army will have extreme difficulty achieving unified action with their heavy dependence on FM radio command and control communications networks.

CHAPTER 5

THE GREEN GRASS OF TECHNOLOGY

"One of the most irritating things a frontline warrior ever faces is the staff officer who greets the warrior's every problem with the news that in five years the difficulty will be eliminated by system X or Y, which will also wreak havoc among the enemy, count bullets, bake beans, and blow the warrior's nose for him."

- Anonymous

That few of these systems are ever as marvelous as the manufacturer claims and that, even if they were, they will not all be fielded are matters of proven fact to the mythical warrior above. Not to mention the fact that down-the-road systems do little to aid in a war beginning tomorrow. Nonetheless, technology that may aid in the re-establishment of confidence in friendly ability to communicate cannot be totally ignored. In this chapter, several promising jam-resistant radio techniques and some non-radio alternatives will be examined. As each is discussed, its strengths and weakness will also be covered.

Among the elements of radio systems that can be improved to add jamming resistance are the antennae. Two categories of antenna changes have been developed; first, highly directional transmission antennae with sufficient coherency and accuracy of aim to avoid enemy detection, and second, automatic nulling antennae which shift their reception pattern away from noise to maximize the signal-to-noise ratio.

The first technique is already in use by several Army systems and does offer considerable resistance to jamming other than along the extended line between the two antenna sites. The disadvantages of this type system are its lack of mobility and the difficulty of aligning or aiming the antenna elements. This lack of mobility is relative, not absolute. Even the staunchest defender of the Signal Corps will admit that these large antenna elements are not as portable as the omni-directional whip on the back of an attack helicopter. Nor will anyone argue that this array is readily adaptable to anything mobile; the cost of trackers and slewing motors or phased arrays to keep the antenna aimed correctly while the platform moves is prohibitive even if the weight and drag penalties were not.

Since each antenna element contributes something to the reception pattern of an antenna array, the addition of sophisticated switching devices to vary the sensitivity of individual antenna elements allows tailoring of the reception pattern of the array. With such tailoring and a device capable of distinguishing signal from noise, the reception pattern may be rapidly altered to provide the best possible signal-to-noise ratio. This works against noise or jamming and may be capable of adding 47 decibels advantage at the receiver.¹ These adaptive arrays are useable both in the air and on the ground.² Developmental work continues toward production of "low profile microstrip antenna elements" to allow aircraft to use adaptive array techniques.³ Further refinements such as adaptive sidelobe cancellers may add even more capability.⁴

¹S. M. Sussman et al., A Survivable Network of Ground Relays for Tactical Data Communication (Technical Report for the MITRE Corp., Bedford, MA: December 1978), p. 8.

²J.U. Beusch et al., Aircraft Nulling Antenna Concepts for Jam-Resistant Secure Voice Communications (Lincoln Laboratories Project Report TST-8 for MIT, Lexington, MA: 13 January 1977), p. 1.

³Donald I. Zulch et al., Project Seek Screen: Vol VI: Communication Performance in ECM and ECCM Technology (Griffiss AFB, NY: Rome Air Development Center, July 1976), p. 27. (SECRET)

⁴Claire, Anti-Jam Policy Study: Vol V, p. 52.

Significant disadvantages to adaptive array applications are not numerous, but they do exist. First, the number of jammers that can be handled by such a system is limited; at best, one less than the number of antenna elements. And the space available to spread the elements over limits the upper boundary of the number of jammers to which an adaptive array can respond.¹ Secondly, the coding necessary to allow the null-processor of the system to distinguish between signal and noise or jamming reduces the intelligibility of the communication.² Thirdly, the characteristics of UHF radio, which is the primary radio for tactical jet aircraft, make directivity extremely difficult (i.e., expensive) to achieve.³

Current literature on anti-jamming radio systems literally abounds with information on digital radio techniques such as frequency hopping, packet networks error detection and correction (EDAC), and spread spectrum systems.

¹Beusch, Aircraft Nulling Antenna, pp. 3 and 8.

²B. Gold, Robust Speech Processing (Lincoln Laboratories Technical Note 1976-6 for MIT, 27 January 1976), p. 2.

³Zulch, Seek Screen VI, p. 23.

These sophisticated electronic countermeasures to jamming offer considerable jamming resistance with manufacturers' claims ranging as high as 60 decibels.¹ The upshot of several years of research and testing of these methods has been the U.S. Air Force's Joint Tactical Information Distribution System (JTIDS). Since this system incorporates most of the techniques found viable and is the closest to operational reality of the jam-resistant radio systems, it will be used to describe and represent this area of communications warfare response.

This system uses spread spectrum pseudo-noise to transmit bursts or packets of digitally coded data. It is programmed to be operational beginning in mid-FY 80 for command and control centers and into fighter aircraft during FY 82.² The system transmits in the 962-1215 megahertz band along with Tacan and IFF.³ The concept is to have so many of these terminals in the battle area that their continuous repeater quality, their proximity

¹J.C. Garrett, Packet Radio Communications (Dallas: Collins Radio/Government Telecommunications Division, 1 August 1976), p. 9-3.

²B. J. Workman, A User's Introduction to the Joint Tactical Information Distribution System (JTIDS) Vol I (Bedford, MA: The MITRE Corp. for U.S. Air Force Systems Command, October 1979), p. 5.

³Ibid., p. 27.

and their inherent noise tolerance will allow communications in even the worst noise environment.¹ This secure system is primarily designed to be used with displays and printers, but does have some voice capability. It has the added feature of providing near-survey-level accuracy position finding with the attendant navigational benefits both for blind bombing and other forms of fire support.

There are some problems with JTIDS, however. First, it is jammable, albeit with difficulty.² Second, JTIDS has a very limited voice capability. A voice circuit through JTIDS uses one-third of a primary net (at the 19.2 Kbit/second data rate required for "decent" voice).³ This virtually assures overcrowding with the number of terminals envisioned for the battle area.

¹Ibid., p. 25.

²Barry M. Leiner, Vulnerability of Packet Radio Networks: Phase I: Final Report: Part 1 (Sunnyvale, CA: Probe Systems, Inc., April 1979), pp 4-13 and 4-20.
Russell E. Lueg and Richard A. Freet, An Introduction to Spread Spectrum Modulation (Langley AFB, VA: Tactical Air Command, 24 October 1975) p. 13.
Don J. Torrieri, Communication Warfare (Adelphi, MD: Harry Diamond Laboratories for U.S. Army Materiel Development and Readiness Command, December 1978), p. 32.
and Don J. Torrieri, Frequency Hopping in a Jamming Environment (Adelphi, MD: Harry Diamond Laboratories for U.S. Army Materiel Development and Readiness Command, December 1978), p. 37.

³Workman, Introduction to JTIDS, p. 38.

The reason for the minuscule number of channels is simply that a binary alphabet is one of the least efficient non-coherent modulation techniques.¹ Third, although concrete intelligibility figures for the operational JTIDS are not yet available, it has been recognized for some time that the more processors involved, particularly digital, the lower the intelligibility.² This lower intelligibility, which seems probable with JTIDS, is generally and strongly believed unacceptable in aerial combat where the speeds involved require that nothing be allowed to degrade the already dangerously slow human reaction times. To be sure, there is a use for secure jam-resistant communications in aerial warfare, but their lack of intelligibility limits their use to areas so far back from the FEBA that the enemy is not a severe threat.³ In fact, most of the uses could be more efficiently performed on the ground using secure telephones. The exceptions being the AWACS, ABCCC, TR-1, tanker aircraft, airborne alert, and other long-duration airborne missions.

¹Claire, Anti-Jam Policy Study: Vol V, p. 124.

²Gold, Robust Speech Processing, p. 2.

³Personal experience plus Claire, Anti-Jam Policy Study: Vol V, p. 75.

A fourth objection to JTIDS is its reliance upon omni-directional antennae.¹ This means that none of the benefits of directional antenna technology can be realized and opens the forward-located nodes of the network to direction-finding by the enemy, to be quickly followed by artillery fire. This is particularly a concern as a JTIDS terminal transmits nearly continuously in its role as a repeater station.² Fifth, with access to unclassified information and an electronic parts supply, a knowledgeable individual should be able to build a jamming system for use against a JTIDS network with about the level of effort demanded by a senior-year university project. By using this paper's bibliography, the entire evolution of JTIDS may be followed with descriptions of mockup hardware, field portable terminals, and computer flow charts.³ No doubt, as JTIDS is improved into operational status, specific modifications will be made to overcome some of these objections, and the objections themselves may not be fatal to the utility of the system.

¹Workman, Introduction to JTIDS, p. 13.

²Leiner, Vulnerability of Packet Radio Networks, p. 4-13.

³Garrett, Packet Radio Communications will provide most of the basic specifications required.

Overall, the JTIDS system, although its technological roots are exposed in unclassified literature, does meet the radioelectronic combat threat head-on. Reliance on proximity of multiple repeaters and significant noise tolerance may well make it the best, although not the total, technical answer to the Soviet threat.

Another piece of technology edging toward operational status is the use of fiber-optics and lasers to replace field wire. Fiber-optic cable does everything that field wire can, and does not have many of wire's objectionable qualities. First, the weight, $4\frac{1}{2}$ pounds of fiber-optic cable can replace approximately eight tons of field wire.¹ While this replacement for wire will initially require nearly the same labor to install, its light weight and tensile strength will undoubtedly soon inspire more rapid means of installation, perhaps even including gun-laid cable. Fiber-optic cable also needs no EMP shielding. Physical vulnerability remains about the same, but with much greater capacity within the cable bypassing damaged circuits is possible for damage short of cable severance. And because of the common raw materials for its manufacture, fiber-optic cable will soon be much cheaper than scarce copper.

¹Allen A. Boraiko, "Harnessing Light by a Thread", National Geographic 156 (October 1979), p. 530.

Because the transmission over fiber-optics is digitally coded, security is easily achieved, as it is aided by the sheer technical difficulty of tapping in.¹ The greatest disadvantage is that it is as difficult to splice as it is for the enemy to tap in.²

While the above technological advances are significant improvements of existing systems, there is additional research into other alternatives. One such attempt is the use of another portion of the electromagnetic spectrum. An ultraviolet short range device has been successfully tested radiating in the sun-blind region of ultraviolet light (2500-2700 Angstroms).³ Jamming vulnerability of this system was not investigated. Undoubtedly other communications research is in progress, but presently the advanced radio techniques and fiber-optics/laser communications hold the most promise.

¹Boraiko, "Harnessing Light", p. 533.

²Torrieri, Communication Warfare, p. 50.

³Where radio uses longer electromagnetic waves below the infra-red portion of the spectrum (generally 10,000 hertz to 300,000 megahertz), this system uses waves shorter than visible light. These waves are measured in Angstroms. One Angstrom is one-one hundred millionth of a centimeter. E.S. Fishburne et al., Voice Communication via Scattered Ultraviolet Radiation: Final Report (Princeton, NJ: Aeronautical Associates of Princeton, Inc., for U.S. Army Electronics Command, February 1976).

CHAPTER 6

WHAT WE REALLY NEED IS . .

This chapter contains three recommendations to which the author has been led by the research for this paper. Two of these three are decidedly controversial and at direct odds with current Army and Air Force doctrine. It is, however, the author's belief that too much time has passed with no adequate results from standard doctrine and that if the Soviet communications warfare superiority is to be challenged, both bold innovation in the short run and greater spending in the long run are required.

The first of these recommendations is that until U.S. forces are able to easily communicate, no matter what the enemy does, CAS should be Army-controlled to reduce the span of communications required. Second, reliance upon radiated systems is as incredibly foolhardy as it is attractive. U.S. armed forces' communications priorities must be changed to favor systems that are not vulnerable to electronic jamming or which are so difficult to jam as to be, for practical purposes, invulnerable. Third, the Department of Defense (DoD) must place greater emphasis on the development of systems

designed to counter and destroy the Soviet radioelectronic combat capability and must assign primary responsibility for this task to a central manager.

As stated earlier, one of the key reasons for the existence of a separate Air Force is the efficiency of centralized management of an asset whose mobility makes its flexible employment across the theater a capability too great to be ignored. As things currently stand, the Air Force retains its CAS primacy purely because it has more capability than organic Army assets under conditions of unopposed communications. Once communications warfare is initiated, the distances from the FEBA to the Air Force's tactical airfields and to the Soviet jammers preclude communication that is responsive enough for CAS using conventional high-speed jet aircraft. Army assets face similar difficulties, but have the capability to stop for pre-attack coordination and are, to begin with, located considerably closer to the action. It is in response to these telecommunications and response time difficulties that the Air Force has begun setting up forward operating locations for the A-10 squadrons. Unless the fixed-wing CAS aircraft can live close enough to the Army to do their coordination by phone prior to takeoff, CAS as currently planned just will not work. Additionally, there is the problem of

high-speed low-altitude target recognition by aircrews. It could be wagered that not one percent of the F-16 or F-4 aircrews could tell the difference between a T-62 and an M-60 at combat altitudes and airspeeds. During the 1978 Reforger exercise, a flight of four F-4s from Ramstein AB, Germany overflew an armored battalion, their target, assembling in an open field. Only one of the eight aircrew members saw any of the elements of that battalion from an 800 foot AGL, 350 knot sweeping turn around that field. This difficulty is normal, in the author's experience. The average hand-picked pilot in the F-4 fast forward air controller (FAC) unit at Udorn Royal Thai Air Force Base in 1971-1974 could not see an uncamouflaged truck at the side of a road for his first two weeks of operations as a FAC. And a cluster of burned-out APCs on the northeast edge of the Plaine des Jarres was still receiving ordnance two years after they were first attacked.

What all this means is that last minute coordination is an absolute necessity and that if radio communications are cut off, high speed jets with rear area basing are not going to have the mandatory timely information to do the close air support job. Nor are they capable enough of identifying the enemy on their own to be let loose in close proximity to friendly troops.

Thus it follows that the Air Force specialists in CAS and their aircraft must be located with the Army for them to be of any use under conditions of other than unopposed communications. More controversially, it means that high-speed jet aircraft incapable of sustaining operations at a forward location are not useable for CAS and should only be used to attack beyond the FSCL where communications are not as critical.¹

The larger ramifications of this argument are that the DoD must give the Army the assets to more adequately deal with the first echelon of the Combined Arms Armies and the Air Force must allocate and locate their CAS dedicated aircraft to and with an Army echelon where the necessary communications to perform CAS can be accessed. The range and endurance of the A-10, the best operational Air Force CAS platform, indicate this tasking control should be to Corps or Division.

The second major change required to restore the close air support capabilities of the TACS is a shift from the ubiquitous radios (particularly HF)² of the

¹Jeremy G. Saye, "Close Air Support in Modern Warfare" Air University Review 31 (Jan-Feb 1980), p. 2 offers a similar argument promoting the AV-8 Harrier.

²Paul J. Crepeau, LPI and AJ Modulation Quality Factors (Washington: Naval Research Laboratory, January 1977), p. 58.

TACS net to landline, either EMP-protected wire or fiber-optics. From experience in Germany, perhaps subsidizing the German Bundespost and upgrading its interfaces with U.S. systems would be the cheapest solution for Central Europe. Communications from the FEBA back to where the TACS could connect with German civil phone lines or to a satellite cross-link could be handled by fiber-optic cable at minimal increase in Signal Corps/Air Force Communications Service manning. Directionally beamed radios with adaptive array receiving antennae offer the best capability for more mobile units.

The above two changes will aid the TACS to "get around" the radioelectronic combat threat and salvage some of Air Force close air support help for the Army, but still so not deal with the threat directly. At present, there is no one agency designated to lead the U.S. forces', hopefully violent, reaction to the Soviet radio-electronic combat forces. This lack fragments the efforts of the services, what little there is. For instance, we have radiation-seeking missiles for all types of radars, none for communications jammers. There are no operational ground-based or artillery or even air-launched communications seekers. The U.S. services' corresponding force to the Soviet radioelectronic combat troops is the still largely unequipped Army CEWI battalion. In other words, with the exception of the CEWI battalion, U.S. forces have done

nothing beyond talking about this threat while blithely practicing and proceeding with communications-intensive CAS plans and Air Force-radiated "Here I am, Ivan" signs at every command post.

So, what should the U.S. do to directly attack this threat? The answer is again controversial. But, in addition to the CAS tasking control arrangement and the shift to relatively jam-proof communications, somebody must be given the capability to destroy Soviet radio-electronic combat assets. This can most economically be done by RADICALLY increasing the Field Artillery. It may even pay to begin the defense of Central Europe with some artillery in direct support of a greatly strengthened CEWI unit. If the Soviet radioelectronic combat assets can be forced back an additional ten nautical miles from the FEBA, their effectiveness would be approximately halved.¹ The increase in Field Artillery would undoubtedly have additional pleasant side effects, for as Napoleon is quoted, "God is on the side with the most artillery." The U.S. and its allies certainly need all the help they can get.

¹Saye, "CAS in Modern Warfare", p. 11.

CHAPTER 7

CONCLUSIONS & RECOMMENDATIONS

There are some conclusions and recommendations which, if followed, may aid in the reestablishment of the TACS' ability to communicate within the next five years. These recommendations are divided into two categories; those immediately useable at little additional cost, and those more complicated and costly answers which require the expense and long lead times common to the fielding of new technology items.

Central to this paper has been the European Tactical Air Control System (TACS) and the assumption that the coordination job it performs is necessary to perform close air support (CAS) with high-speed conventional fighter aircraft. The TACS does this primarily with radios that connect the Army's communications to the Air Force's and then extends those communications throughout the Air Force structure for the generation and control of the fighter assets. These radio communications face threats both from interference due to the sheer number of friendly radios competing for frequency space and from the Soviet/Warsaw Pact radioelectronic combat forces.

Current procedures to meet the frequency space competition appear to barely cope, as long as there is

no strain on the system. With the difficulties of combat and poor weather, the system is inadequate. Inadequate also are the procedures designed to reduce the effects of the enemy's radioelectronic combat forces. These procedures are, in large, either admissions of defeat or wishful thinking. Neither a technical, nor a procedural answer is adequate; there must be a mix of the two to adequately handle both self- and enemy-induced communications interference.

Recommendations for immediate answers are funds-constrained into the first category, admissions of communications defeat. And if the communications war is lost, the U.S. may lose along with it the ability to fight out-numbered and to avoid total European defeat. For a solution to fit the requirements of this author, it must be feasible, and it must be possible to put it into operation within a few months. First, the best intelligence estimates of the actual numbers of radioelectronic combat elements opposing U.S. forces drives one to the conclusion that dependence upon radiated communications is nearly the same as calling artillery fire onto friendly positions.¹

¹William D. George et al., Soviet/Warsaw Pact Radio Electronic Combat Capability (U.S. Air Force Electronic Warfare Center, October 1978). (SECRET) and Edmund J. Mitchell, Joint Tactical Information Distribution System Threat Assessment (Hanscom AFB, MA: The MITRE Corp., for Electronic Systems Division, USAF, 6 January 1978) (SECRET) and many others, unclassified.

Thus, until sufficient jam-proof communications are developed to allow communications nets to function as described in Air Force and Army manuals, there are going to have to be changes in CAS procedures. CAS is precisely where the difficulty looms the largest. The rapidly changing ground situation demands support that is directly responsive to the ground commander. If the proposal is to respond to his needs by means of easily jammed radio, the situation's improvement or deterioration will depend on resources the ground commander directly controls. Now, accepting that, with current capabilities, air support of the ground commander elicited via radio is infeasible; the only viable option immediately available is to move the CAS forces close enough to the ground commander that the necessary coordination can be accomplished with existing landline assets. And since this coordination must occur with the aircraft still on the ground, geographic proximity is also required to insure sufficiently swift response times that the ground situation does not unacceptably change while the aircraft is en route to the target. The final argument for physical proximity is that CAS coordination must be done within the range limitations of current wire resources.

The other side of this coin has impact, also. If Air Force aircraft currently planned for CAS use have characteristics that make forward basing impracticable or impossible, their contribution to combat must be planned to consist of what they can do beyond the Fire Support Coordination Line (FSCL). In other words, U.S. failure to keep up with communications warfare drives the command and control of airpower back toward the procedures used in World War I and II.

Near term options can help to reduce these unfavorable trends, however. First among these is to use existing funds to increase capability, availability, and technology of the one existing system invulnerable to electronic jamming--wire. Review of the literature and experience indicate two distinctly feasible possibilities. First, an increased liaison and exercise of the Bundeswehr-leased portion of the German civil telephone system and second, as much impetus as possible to the replacement of field wire and cable by fiber-optic cable whose light weight and low cost should allow extending line communication much further forward than is now contemplated.

While radiated communications will always be vulnerable to some extent, the Joint Tactical Information Distribution System (JTIDS) and its immediate ancestors occupy a great majority of the literature pertaining to radiated systems with some proven jam-resistance.

As this system comes on line it may restore U.S. forces' radiated communication capability to the extent that rear-based CAS forces may again be possible.

But all of the above are only a partial solution and do not directly assault the Soviet's capability to deny communications. To move or, by destruction, roll back the Soviet's radioelectronic combat forces to the point where they lose effectiveness demands, at its simplest, a dramatic increase in artillery and the assets to aim it. Driving these soft-skinned targets further back from the FEBA decreases their capability as the square of their distance from our receivers. Artillery targeted by direction-finding assets and systems such as TEREK, with the overall coordination of a radically upgraded Combat Electronic Warfare and Intelligence (CEWI) operation, offers continued use of existing radios and, at least, some additional casualties to the Soviets.

Further research into modes of attack on this problem is definitely warranted and first among them should be a threat analysis to answer how much artillery this effort would require. Additional weaponry is probably also a necessity. For example, a tube or rocket launched communications seeker should not require much change from existing radar seekers and offers enough added capability to justify the cost.

In the end though, failure to assault this problem has already reduced, or at the least thrown into doubt, the Air Force's ability to closely support the Army. And while this paper's solutions to the TACS communications warfare problem are, in some cases, quite controversial, this author's research has led him directly to the conclusion that if we are to be able to use USAF close air support as we fight the Central European battle, such measures must be taken in the very near future. If this situation is left uncorrected, it is only a matter of time before we find out how badly our communications warfare inferiority can hurt us and our allies.

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